WHAT IS CLAIMED IS:

1. A variable gain amplifier comprising:

an input terminal of the variable gain amplifier for sequentially inputting a first signal voltage and a second signal voltage;

an output terminal of the variable gain amplifier for outputting a difference signal between the first and second signal voltages;

an operational amplifier including a positive input terminal to which a reference voltage is inputted, a negative input terminal connected through a signal path to the input terminal of the variable gain amplifier, and an output terminal connected to the output terminal of the variable gain amplifier;

an input capacitor provided in the signal path extending from the input terminal of the variable gain amplifier to the negative input terminal of the operational amplifier, the input capacitor having one end connected through the signal path to the input terminal of the variable gain amplifier, and having the other end connected through the signal path to the negative input terminal of the operational amplifier;

a feedback capacitor having a capacitance set variable, provided between the negative input terminal and the output terminal of the operational amplifier;

a first switch device for connecting or disconnecting the signal path;

a second switch device for connect or disconnecting an input of the reference voltage to the one end of the input capacitor; and

a third switch device for connecting or disconnecting the negative input terminal and the output terminal of the operational amplifier.

2. The variable gain amplifier according to claim 1, wherein the feedback capacitor includes a plurality of capacitors, and, by one or more switch devices, one or more capacitors necessary for setting a capacitance of the feedback capacitor can be selected from the plurality of capacitors.

3. A variable gain amplifier outputting a difference signal between a first signal voltage and a second signal voltage, wherein the first signal voltage and the second signal voltage are sequentially inputted, the first signal voltage and the second signal voltage are converted to charges to generate the difference signal therebetween, and a gain is adjusted according to an amplitude of the difference signal to output the difference signal having an output level adjusted.

4. A solid-state imaging device in which an optical signal is converted into an electric signal, the electric signal is converted into a digital signal, and the digital signal is outputted, comprising:

(a)a plurality of photoelectric conversion devices arrayed in rows and columns, for converting the optical

signal into the electric signal and outputting a signal voltage;

(b)a variable gain amplifier provided for each of the columns, the variable gain amplifier including

(i)an input terminal of the variable gain amplifier for sequentially inputting a first signal voltage and a second signal voltage,

(ii)an output terminal of the variable gain amplifier for outputting a difference signal between the first signal voltage and the second signal voltage,

(iii)an operational amplifier having a positive input terminal for inputting a reference voltage, a negative input terminal connected through a signal path to the input terminal of the variable gain amplifier, and an output terminal connected to the output terminal of the variable gain amplifier,

(iv)an input capacitor provided in the signal path extending from the input terminal of the variable gain amplifier to the negative input terminal of the operational amplifier, the input capacitor having one end connected through the signal path to the input terminal of the variable gain amplifier and having the other end connected through the signal path to the negative input terminal of the operational amplifier,

(v)a feedback capacitor having a capacitance set variable, provided between the negative input terminal and the output terminal of the operational amplifier,

(vi)a first switch device for connecting or disconnecting the signal path,

(vii)a second switch device for connecting or disconnecting an input of the reference voltage to one end of the input capacitor, and

(viii)a third switch device for connecting or disconnecting the negative input terminal and the output terminal of the operational amplifier; and

(c)an analog/digital conversion circuit for converting the difference signal outputted from the variable gain amplifier into a digital signal.

5. The solid-state imaging device according to claim 4, further comprising:

a plurality of capacitors constituting the feedback capacitor; and

a plurality of switch devices,

wherein one or more capacitors necessary for setting the capacitance of the feedback capacitor can be selected from the plurality of capacitors by one or more switch devices among said plurality of switch devices.

6. A solid-state imaging device in which an optical signal is converted into an electric signal, the electric signal is converted into a digital signal, and the digital signal is outputted, comprising:

a plurality of photoelectric conversion devices arrayed in rows and columns, for converting the optical signal into the electric signal and outputting a signal

voltage;

a variable gain amplifier for sequentially inputting a first signal voltage obtained by converting an optical signal into the electric signal and the second signal voltage obtained by initializing the photoelectric conversion device, converting the first signal voltage and the second signal voltage into charges to generate the difference signal therebetween, and adjusting a gain according to an amplitude of the difference signal to output the difference signal having an output level adjusted.

7. The solid-state imaging device according to claim 4, wherein each of the photoelectric conversion devices further includes:

(i)a photodetector; and

(ii)an insulated gate field effect transistor for optical signal detection, provided adjacently to the photodetector, the insulated gate field effect transistor for optical signal detection including a heavily doped buried layer for storing photo-generated charges generated by the photodetector, the heavily doped buried layer being provided around a source region under a channel region below a gate electrode, and

the first signal voltage and the second signal voltage are outputted from the source region of the insulated gate field effect transistor for optical signal detection.

8. An optical signal reading method for converting an optical signal into an electric signal, converting the electric signal into a digital signal, and then outputting the digital signal, the optical signal reading method comprising the steps of:

irradiating a photoelectric conversion device with an optical signal;

outputting a first signal voltage obtained by converting the optical signal into an electric signal;

converting the first signal voltage into charges and storing the charges;

outputting a second signal voltage at an initialization of the photoelectric conversion device;

converting the second signal voltage into charges;

generating a difference signal between the first signal voltage stored as the charges and the second signal voltage converted into the charges, adjusting a gain according to an amplitude of the difference signal, and generating a difference signal having an output level adjusted; and

converting the difference signal having the output level adjusted into a digital signal.

9. The optical signal reading method according to claim 8, wherein a plurality of the photoelectric conversion devices are arrayed in rows and columns, and the difference signal having the output level adjusted is outputted for each column.

10. An optical signal reading method according to claim 9, wherein each of the photoelectric conversion devices includes

(i)a photodetector, and

(ii)an insulated gate field effect transistor for optical signal detection, provided adjacently to the photodetector, the insulated gate field effect transistor for optical signal detection including a heavily doped buried layer for storing photo-generated charges generated by the photodetector, the heavily doped buried layer being provided around a source region under a channel region below a gate electrode, and

the first signal voltage and the second signal voltage are outputted from the source region of the insulated gate field effect transistor for optical signal detection.

11. The optical signal reading method according to claim 10, wherein a variable gain amplifier is provided in each of the columns, the variable gain amplifier includes

(i)an input terminal for sequentially inputting the first signal voltage and the second signal voltage,

(ii)an output terminal for outputting a difference signal between the first signal voltage and the second signal voltage,

(iii)an operational amplifier having a positive input terminal for inputting a reference voltage, a

negative input terminal connected to an input terminal of an integrating circuit, and an output terminal connected to an output terminal of the integrating circuit,

(iv)an input capacitor provided in a signal path extending from the input terminal of the integrating circuit to the negative input terminal of the operational amplifier, the input capacitor having one end connected through the signal path to the input terminal of the integrating circuit and having the other end connected through the signal path to the negative input terminal of the operational amplifier,

(v)a feedback capacitor provided between the negative input terminal and the output terminal of the operational amplifier,

(vi)a first switch device for connecting/disconnecting a signal path extending from the input terminal of the integrating circuit to one end of the input capacitor,

(vii)a second switch device for connecting/disconnecting an input of the reference voltage to one end of the input capacitor, and

(viii)a third switch device for connecting/disconnecting the negative input terminal and the output terminal of the operational amplifier, and

the method comprises the steps of

(a)adjusting a gain by adjusting a ratio of a feedback capacitance with respect to an input capacitance

so as to set the difference signal within a requested range of an input voltage of an analog signal at converting the difference signal into the digital signal;

(b)transferring photo-generated charges generated by the photodetector and storing them in the heavily doped buried layer of the insulated gate field effect transistor for optical signal detection, while connecting the second and third switch devices to initialize the input capacitor and the feedback capacitor;

(c)then, connecting the first and third switch devices, disconnecting the second switch device, outputting a signal voltage according to the photo-generated charges stored in the heavily doped buried layer from the insulated gate field effect transistor for optical signal detection, and then converting the signal voltage into charges and storing them in the input capacitor as charges;

(d)then, connecting the second switch device and disconnecting the third switch device, so as to transfer the charges of the first signal voltage stored in the input capacitor to the feedback capacitor;

(e)then, discharging the photo-generated charges remaining in the heavily doped buried layer to initialize the photoelectric conversion device, thereafter connecting the first switch device, disconnecting the second and third switch devices, outputting a second signal voltage in the initialized state of the

photoelectric conversion device from the insulated gate field effect transistor for optical signal detection, then converting the second signal voltage into charges, and storing a difference between the charges of the first signal voltage and the charges of the second signal voltage to generate the difference signal; and

(f)then, adjusting a gain by adjusting a ratio of the input capacitor and the feedback capacitor so as to set the difference signal within a range of an analog input voltage which is converted into the digital signal, and outputting the difference signal having the output level adjusted from the operational amplifier to each of the columns.

12. A solid-state imaging device comprising:

a plurality of photoelectric conversion devices arrayed in rows and columns, for converting an optical signal into an electric signal and outputting the electric signal;

an amplifier provided for each of the columns, for sequentially inputting a first signal voltage obtained by converting the optical signal into the electric signal, and a second signal voltage obtained by initializing the photoelectric conversion device, for converting the first signal voltage and the second signal voltage into charges, and for outputting a difference signal between the first signal voltage and the second signal voltage;

a video signal output terminal for outputting the

difference signal outputted from the amplifier as a video signal corresponding to the optical signal; and

a switching means provided between the amplifiers of at least two columns, for mixing the difference signals of at least two columns.

13. The solid-state imaging device according to claim 12, wherein the amplifier is a variable gain amplifier in which the first signal voltage and the second signal voltage are sequentially inputted, the first signal voltage and the second signal voltage are converted into charges, the difference voltage therebetween is generated, a gain is adjusted according to an amplitude of the difference signal, and a difference signal adjusted in a output-level is outputted.

14. The solid-state imaging device according to claim 13, wherein each of the photoelectric conversion devices includes:

(i)a photodetector; and

(ii)an insulated gate field effect transistor for optical signal detection, provided adjacently to the photodetector, the insulated gate field effect transistor for optical signal detection including a heavily doped buried layer for storing photo-generated charges generated by the photodetector, the heavily doped buried layer being provided around a source region under a channel region below a gate electrode, and

the first signal voltage and the second signal

voltage are outputted from the source region of the insulated gate field effect transistor for optical signal detection.

15. An optical signal reading method of a solid-state imaging device which includes

(i)a plurality of photoelectric conversion devices arrayed in rows and columns, for converting an optical signal into an electric signal and for outputting the electric signal,

(ii)a plurality of amplifiers provided for the respective columns, each of the amplifiers being for sequentially inputting a first signal voltage obtained by converting the optical signal into the electric signal, and a second signal voltage obtained by initializing the photoelectric conversion device, for converting the first signal voltage and the second signal voltage into charges, and for outputting a difference signal therebetween, and

(iii)a video signal output terminal for outputting the difference signal outputted from the amplifier as a video signal corresponding to the optical signal,

the method comprising the steps of;

mixing the difference signals from the amplifiers of at least two columns; and

outputting an output signal from the amplifier.

16. The optical signal reading method according to claim 15, wherein each of the photoelectric conversion devices includes

(i)a photodetector, and

(ii)an insulated gate field effect transistor for optical signal detection, provided adjacently to the photodetector, the insulated gate field effect transistor for optical signal detection including a heavily doped buried layer for storing photo-generated charges generated by the photodetector, the heavily doped buried layer being provided around a source region under a channel region below a gate electrode, and

the first signal voltage and the second signal voltage are outputted from the source region of the insulated gate field effect transistor for optical signal detection.

17. The optical signal reading method according to claim 16, wherein an amplifier and a pixel mixing switch are provided in each of the columns, the amplifier includes

(i)an input terminal for sequentially inputting a first signal voltage and a second signal voltage,

(ii)an output terminal for outputting a difference signal between the first signal voltage and the second signal voltage,

(iii)an operational amplifier having a positive input terminal for inputting a reference voltage, a negative input terminal connected to an input terminal of the amplifier, and an output terminal connected to an output terminal of the amplifier,

(iv)an input capacitor provided in a signal path extending from the input terminal of the amplifier to the negative input terminal of the operational amplifier, the input capacitor having one end connected through the signal path to the input terminal of the amplifier and having the other end connected through the signal path to the negative input terminal of the operational amplifier,

(v)a feedback capacitor provided between the negative input terminal and output terminal of the operational amplifier,

(vi)a first switch device for connecting/disconnecting the signal path,

(vii)a second switch device for connecting/disconnecting an input of the reference voltage to the one end of the input capacitor, and

(viii)a third switch device for connecting/disconnecting the negative input terminal and output terminal of the operational amplifier, and

the pixel mixing switch connects the negative input terminals the operational amplifiers of at least two columns, and

the method comprises the steps of

(b)transferring photo-generated charges generated by the photodetector to the heavily doped buried layer of the insulated gate field effect transistor for optical signal detection and storing the charges therein, while connecting the second and third switch devices to

initialize the input capacitor and the feedback capacitor;

(c)then, connecting the first and third switch devices, disconnecting the second switch device and the pixel mixing switch device, and thus outputting a first signal voltage corresponding to the photo-generated charges stored in the heavily doped buried layer from the insulated gate field effect transistor for optical signal detection, and converting the first signal voltage into charges and storing the charges in the input capacitor;

(d)then, connecting the second switch device, disconnecting the third switch device, and thus transferring the charges of the first signal voltage stored in the input capacitor to the feedback capacitor; and

(e)then, discharging the photo-generated charge remaining in the heavily doped buried layer to initialize the photoelectric conversion device, thereafter connecting the first switch device and the pixel mixing switch device, disconnecting the second and third switch devices, outputting a second signal voltage in the initialized state of the photoelectric conversion device from the insulated gate field effect transistor for optical signal detection, thus converting the second signal voltage into charges and storing them in the input capacitor, then mixing the charges of the first signal voltages from the photoelectric conversion devices of at

least two columns and the charges of the second signal voltage therefrom through the pixel mixing switch device connecting the negative input terminals of the operational amplifiers of the at least two columns, and then outputting an output signal from the operational amplifier.